



Office of Aeronautics & Space
Transportation Technology

National Aeronautics and Space Administration

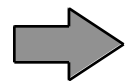
An Aviation Safety Research Investment Strategy:

Report of the ASIST Team
to the OASTT Executive Council

Charles H. Huettner, Chair
April 23, 1997

<http://www.aero.hq.nasa.gov/oastthp/curevent/asist.htm>

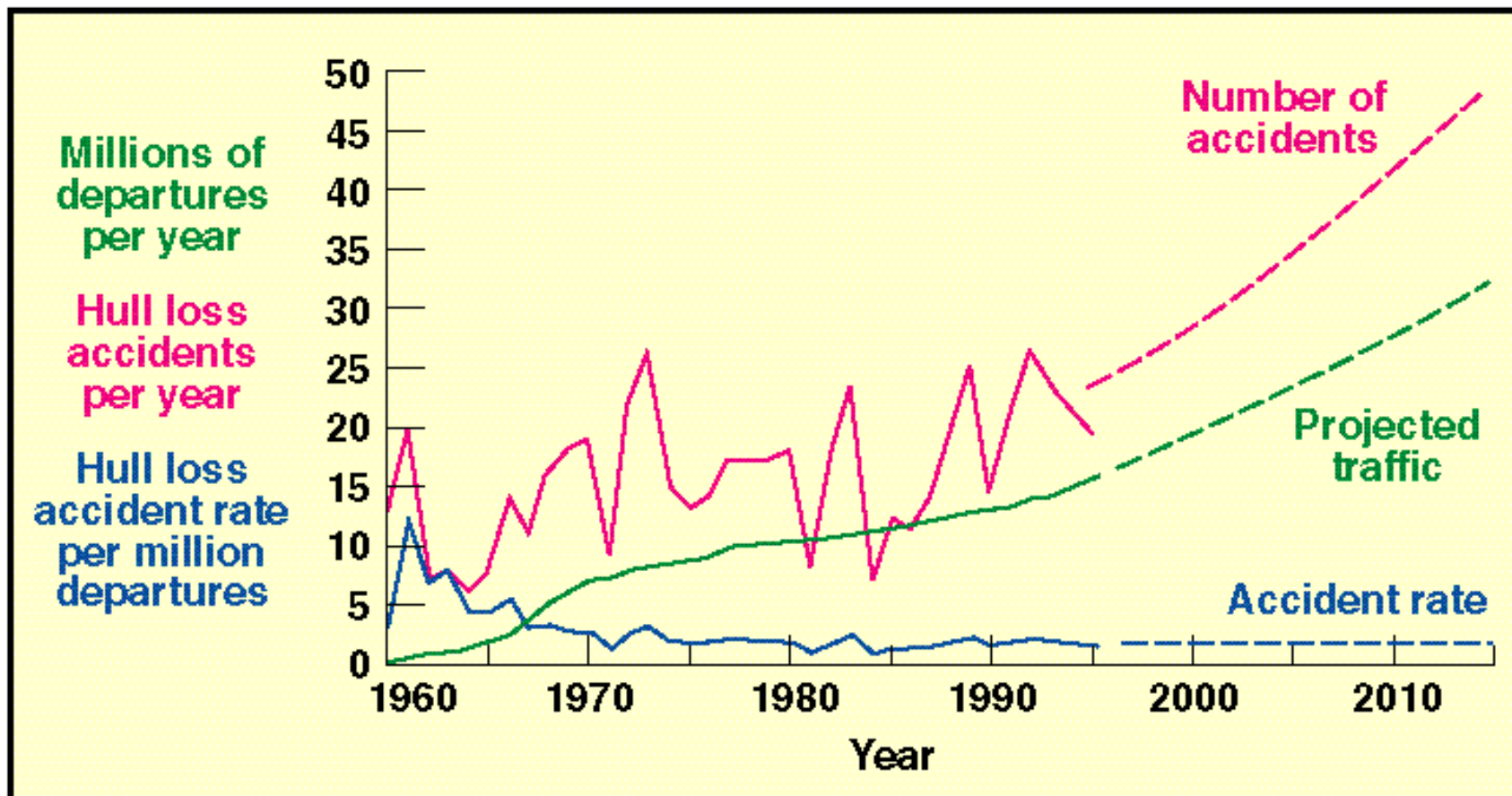
ASIST EC Presentation Agenda



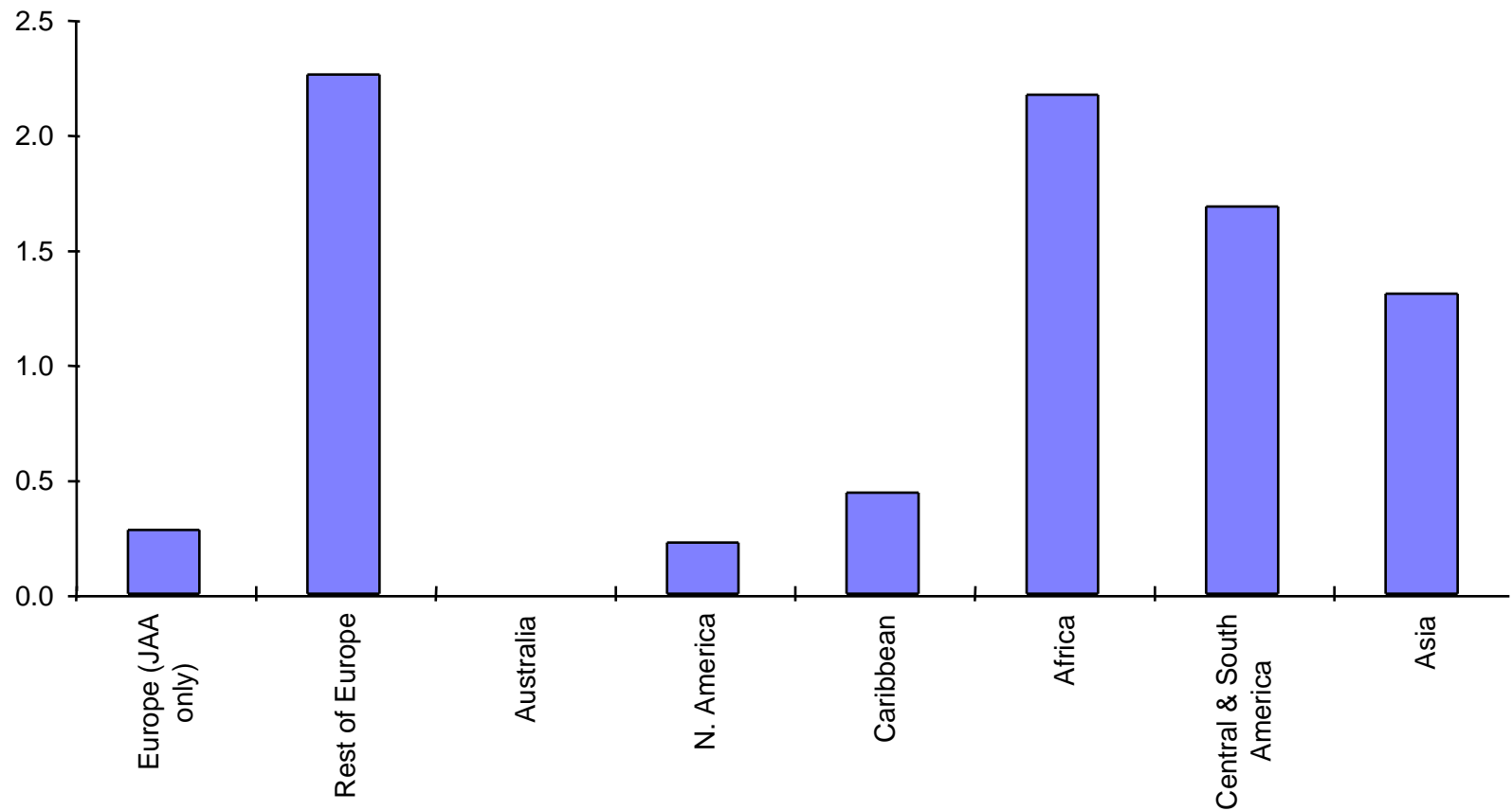
1. **Safety Research: *WHY* (C. Huettner - 5 min)**
2. **Systems Approach to Improving Safety (C. Huettner - 10 min)**
3. **ASIST Process (C. Huettner - 10 min)**
4. **Safety Research: *WHAT* (40 min)**
 - Accident Prevention (Mike Lewis - 20 min)
 - Accident Mitigation (Huey Carden - 5 min)
 - Aviation System-wide Monitoring, Modeling & Simulation (Tom Edwards - 15 min)
5. **Recommendations (C. Huettner - 30 min)**
6. **Issues (C. Huettner - 10 min)**

Projected Hull Loss —

Assuming Current Accident Rate Does Not Decline
But Traffic Increases as Forecast

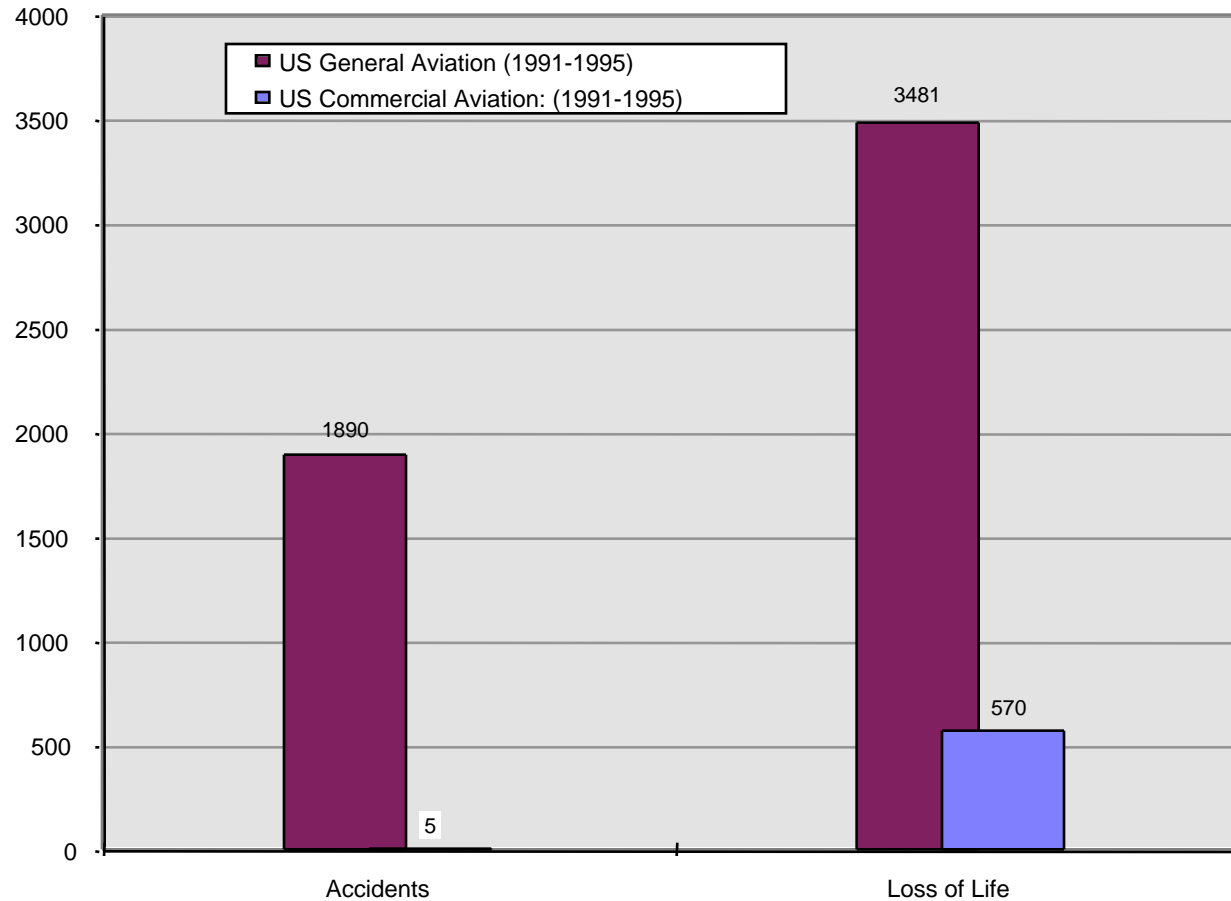


Fatal Accident Rate (1986-1996) (accidents per million flights)



A Comparison of Fatal Accidents

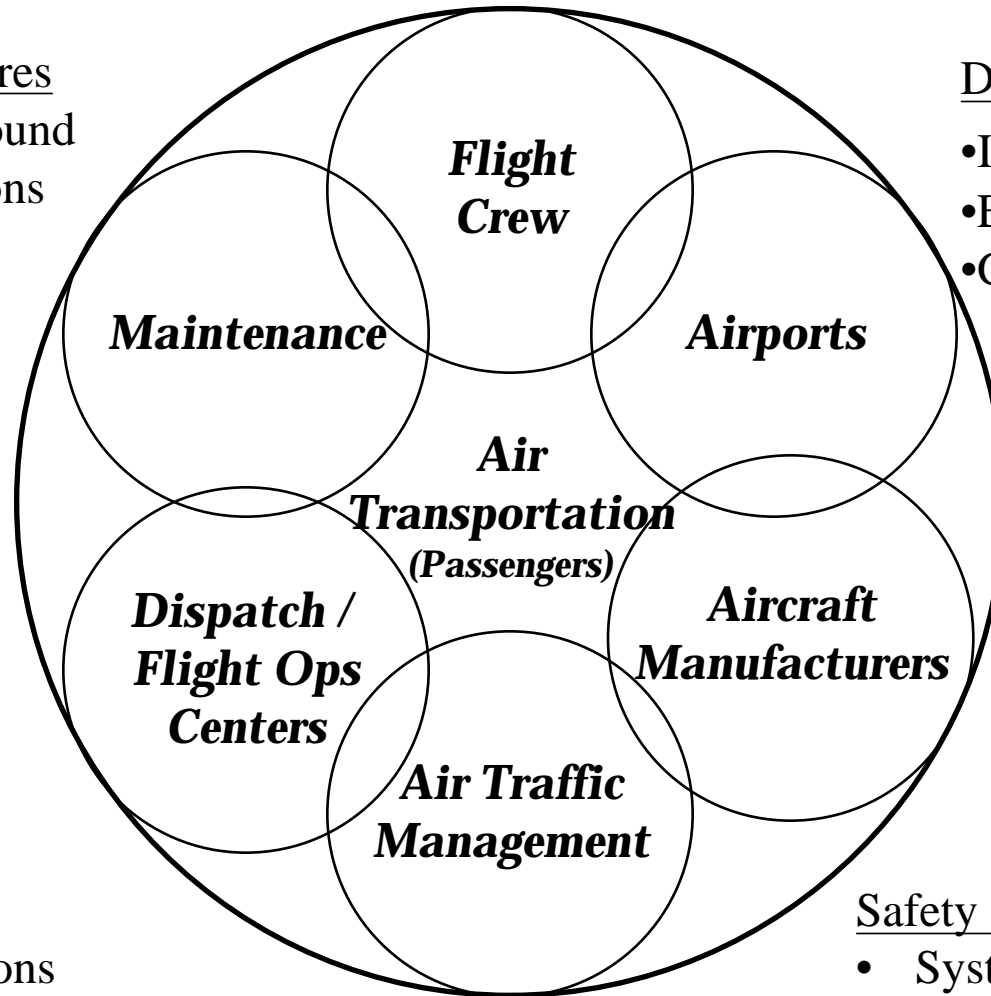
(Commercial Airlines vs. General Aviation)



Integrated Aviation System Aeronet

Six Aviation Cultures

- Common Background
- Laws & Regulations
- FAA Oversight
- Industry Assoc.
- Industry Forums



Drivers for Change

- Information Technology
- Economics
- Globalization

Change

- Communications
- Decision Making
- Roles of People
- Pace of Change

Safety Opportunity

- System Monitoring
 - Aircraft/System Operations
 - Operating Procedure Effectiveness
 - System Reliability
 - Accident / Incident Investigation

Aviation Safety Research

“We will achieve a national goal of reducing the fatal aircraft accident rate by 80% within 10 years.”

President William J. Clinton, February 12, 1997

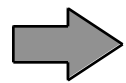
“We have an opportunity of a lifetime to make aviation safer in ways we never dreamed possible.”

Charlie Huettner, 1997

- **Information technology revolution**
- **Top level support**
 - **Government - President, Congress & Agency Administrators**
 - **Industry - CEOs**
 - **Public & Press - Intense interest**
- **NASA initial investment of one-half billion dollars**
- **Transition to new Air Traffic Management system**
- **Retrofit of aviation fleet to digital Com, Nav, & Surveillance (CNS) technologies**

ASIST EC Presentation Agenda

1. Safety Research: *WHY* (C. Huettner - 5 min)



2. Systems Approach to Improving Safety
(C. Huettner - 10 min)

3. ASIST Process (C. Huettner - 10 min)

4. Safety Research: *WHAT* (40 min)

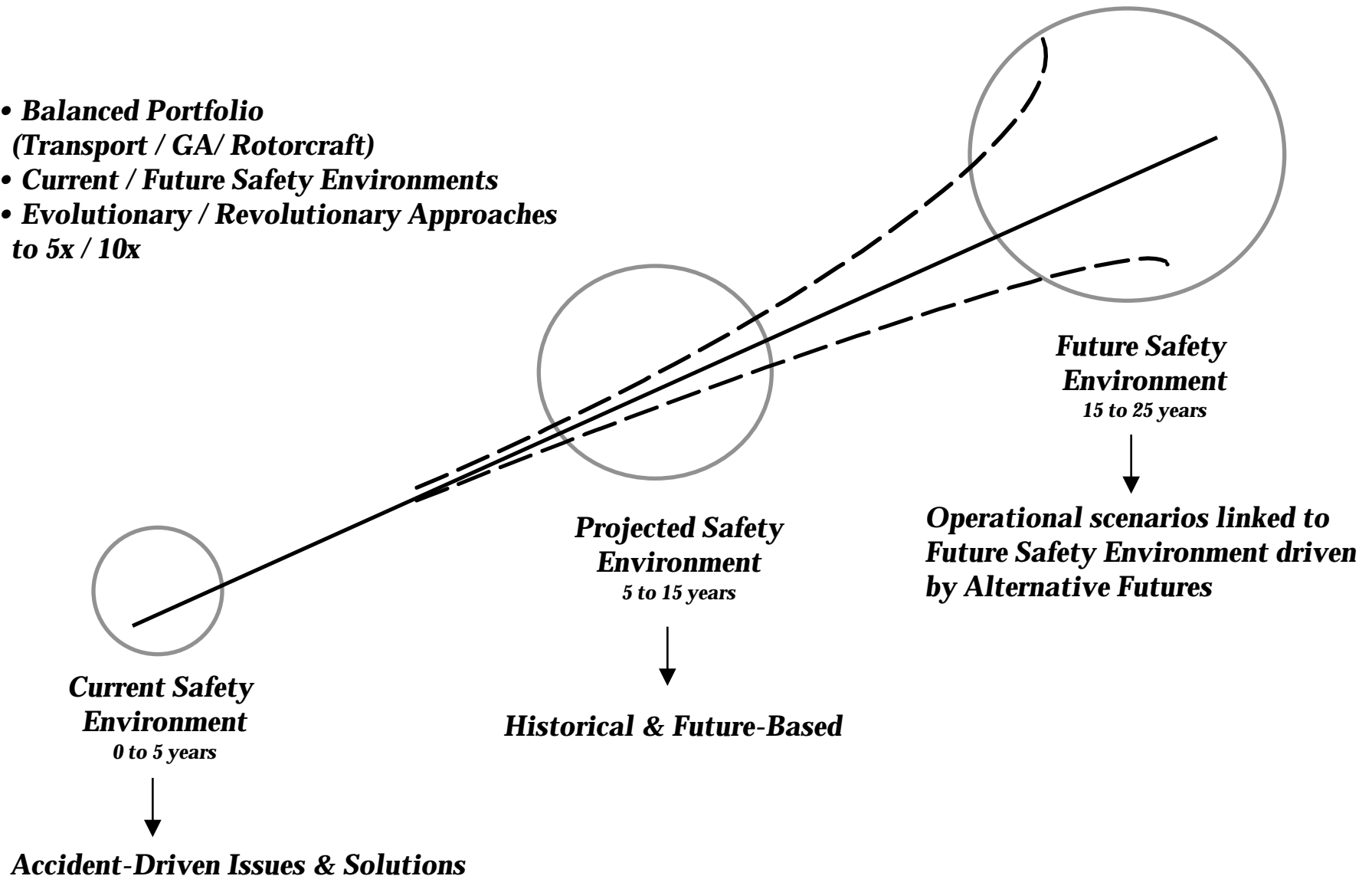
- Accident Prevention (Mike Lewis - 20 min)
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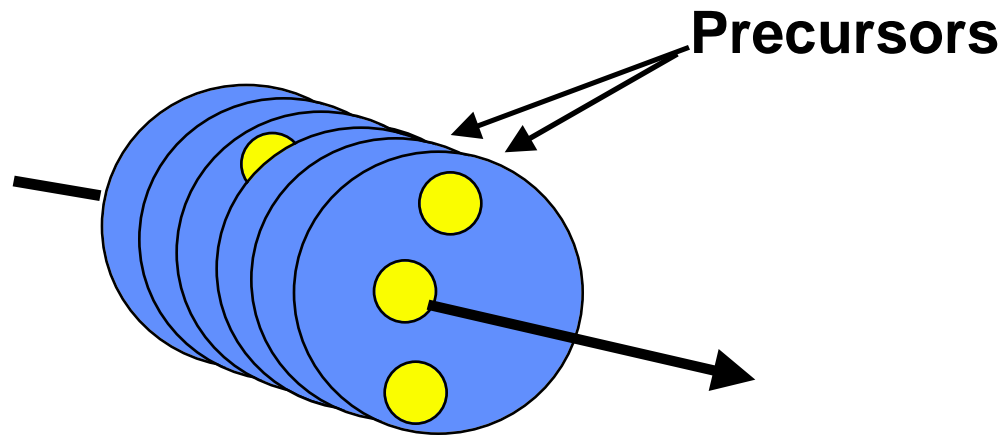
Systems Approach to Improved Safety

- **Balanced Portfolio**
(Transport / GA/ Rotorcraft)
- **Current / Future Safety Environments**
- **Evolutionary / Revolutionary Approaches**
to 5x / 10x



NASA's Role in Aviation Safety:

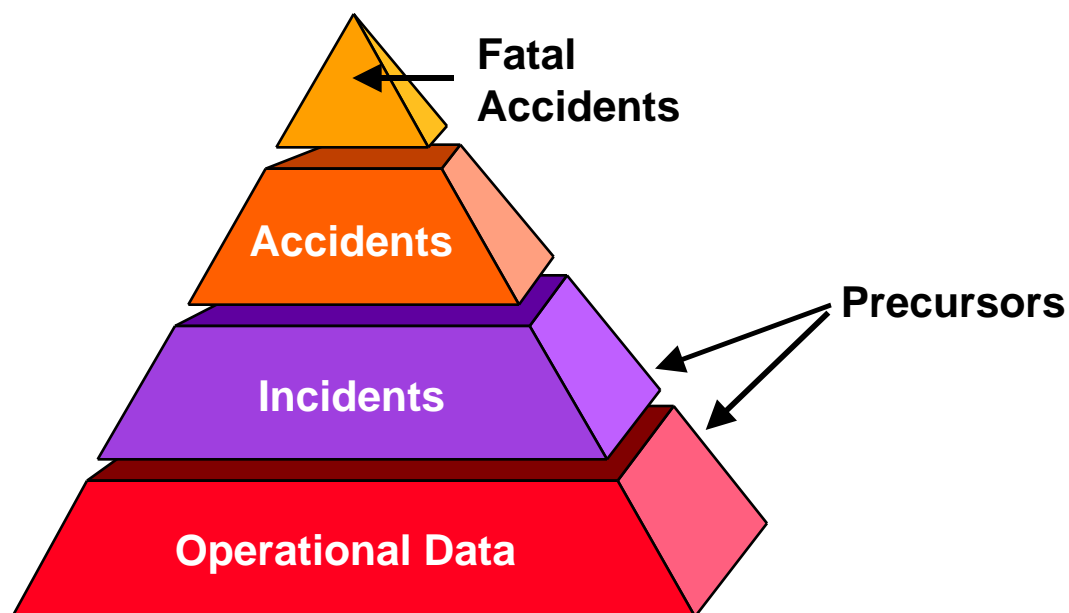
*To Develop the Enabling Technology to Eliminate
Accident Precursors*



Alignment = Incident or Accident

Metrics

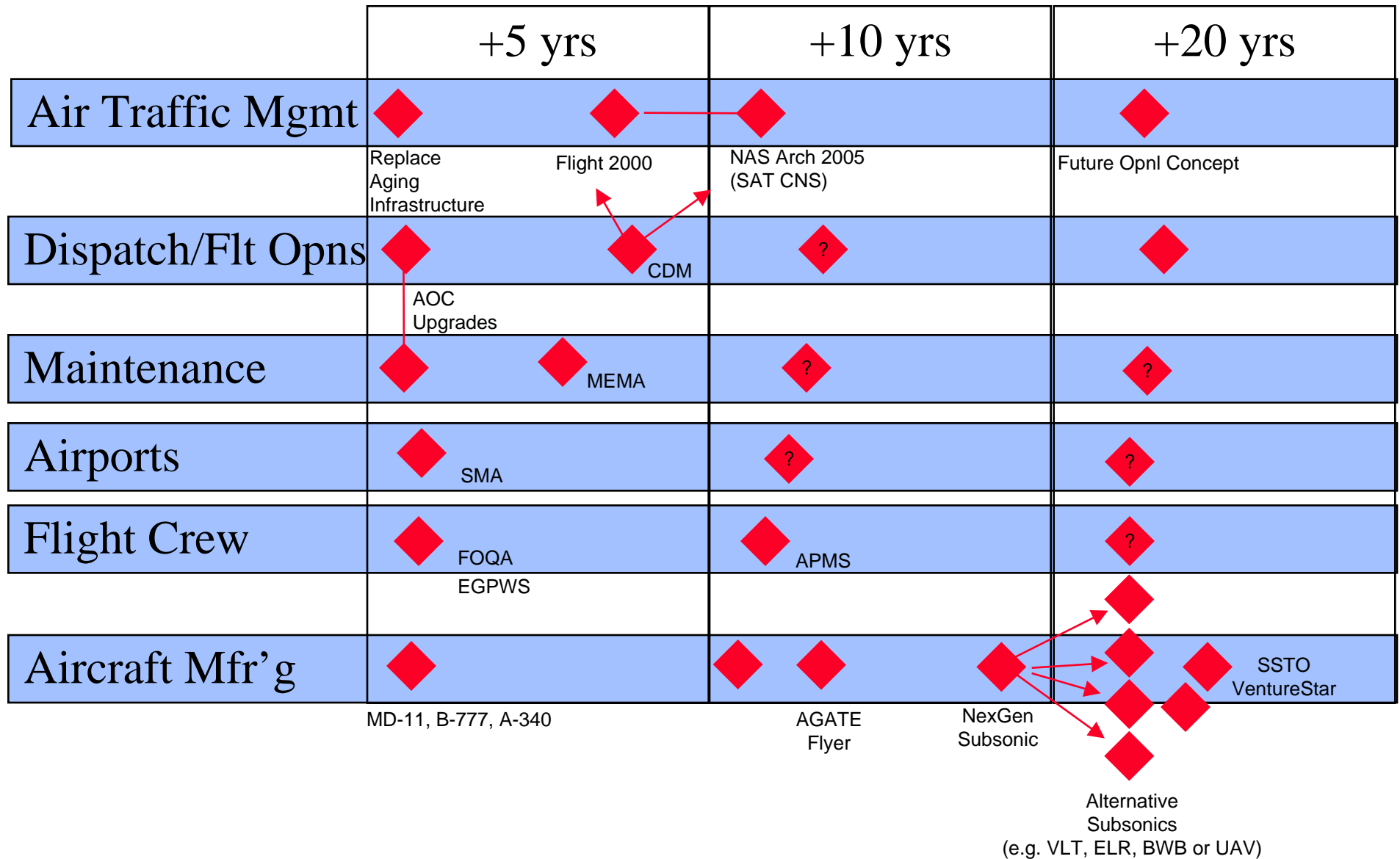
- The ultimate metric is fatal accidents
- Fatal accidents are difficult to use as a metric for measuring research progress
 - Few fatal accidents occur per year
 - The circumstances of fatal accidents vary greatly
- The challenge is to accurately identify accident precursors from the much larger set of incidents or from operational data such as flight data recorders
- The understanding between accidents and accident precursors does not exist today



Transport Approach & Landing Accident Precursor Study

- **Interdisciplinary panel to determine precursors**
 - Systems, ATC, Pilots, Mechanics, Human Factors, etc.
- **Membership includes:**
 - Boeing in support of Flight Safety Foundation Initiative
 - Three NASA representatives
 - Three FAA representatives
 - NTSB
- **Study planned to begin next month**

Future Scenarios Based on Technology Insertions



ASIST EC Presentation Agenda

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Aviation Safety Investment Strategy Team (ASIST)

Organization:

Tri-Lateral Group: NASA, FAA, DoD

**NASA/FAA Coordinating Committee: Bob Whitehead, George Donohue,
Guy Gardner, Chris Hart, Neil Planzer**

Chair: Charlie Huettner

NASA Code R: Rich Christiansen, Lee Holcomb

FAA: Jan Brecht-Clark, Chuck Hedges, Ava Mims, Chris Seher

DoD: Don Dix

Weather Service: Julian Wright, Susan Zevin

Industry: NASA - AAC, FAA -RE&D Advisory Committee, ITLT

Sub-Team Focus Areas:

- » **Human Error**
- » **Flight Critical Systems & Information Integrity**
- » **Weather**
- » **Aviation System-wide Monitoring, Modeling & Simulation**
- » **Human Survivability**

Sub-Team Focus Areas

Human Error Team Government Members:

- *Doug Arbuckle, NASA LaRC 757-864-1718
- *Cynthia Null, NASA ARC 415-604-1260
- Kathy Abbott, FAA
- Tom McCloy, FAA
- Maris Vikmanis, DoD

Flight Critical Systems & Information Integrity Team Government Members:

- *George Finelli, NASA LaRC 757-864-1700
- **Joel Sitz, NASA DFRC 805-258-3666
- Mike Basehore, FAA
- Hugh Gray, NASA LeRC
- Feisal Keblawi, FAA
- Michael Shafto, NASA ARC
- Duane Rubertus, DoD

*Team Lead/Co-Lead

**DFRC Rep

Sub-Team Focus Areas - 2

Weather Team Government Members:

- *HaeOk Lee, NASA LeRC 216-433-3900
- *Mike Lewis, NASA LaRC 757-864-7655
- Mark Potapczuk, NASA LaRC
- Dave Pace, FAA
- AF Col. David Bonewitz, DoD
- Dorothy Haldeman, National Weather Service

Aviation System-wide Monitoring, Modeling & Simulation Team Government Members:

- *Tom Edwards, NASA ARC 415-604-4465
- Mary Connors, NASA ARC
- Carolyn Edwards, FAA
- Vic Badia, DoD

Human Survivability Team Government Members:

- *Huey Carden, NASA LaRC 757-864-4151
- Gary Frings, FAA
- James Hicks, DoD

*Team Lead/Co-Lead

Additional Government Team Membership

Rotorcraft:

Sandra Hart, NASA ARC

415-604-6072

General Aviation:

Mike Durham, NASA LaRC

757-864-3863

NASA HQ Representatives:

Ralph A'Harrah

Joe Elliott

Bob Luddy

Bob Pearce

Herb Schlickemaier

Carrie Walker

202-358-2098

NASA-FAA Liaison:

John Burks

202-267-3235

ASIST Participating Organizations

Advanced Nav. & Position Corp.

AIA

AIAA

Alaska Airlines

Allied Signal

Allison Engine Company

ALPA

AMA

AOPA Air Safety Foundation

ARCCA

ARINC

Arizona State Univ.

ARNAV Systems, Inc.

Assoc. of Flight Attendants

ATA

Aviation Research Inc.

AvioniCom

Battelle

Bell Helicopter/ Textron

Boeing

Boeing Helicopter Group

Boston University

Cessna Aircraft Co.

Delta Airlines

DoD/ Air Force Safety Center

DoD/ ARMY Safety Center

DoD/ NAV Air

DoD/ Naval Safety Center

DoD/ NAVMAR

DoD/ NAWCAD, Pax River

DoD/ USAF, 416FLTS

DoD/ USAF/WPAFB

DoD/ WL/XPK

DOT/ Volpe Center

Embry-Riddle Aeronautical Univ.

ERC Inc.

FAA/ AAR

FAA/ AAR (LaRC)

FAA/ ACE

FAA/ AFS

FAA/ AIR

FAA/ AND

FAA/ ANM

FAA/ ARA

FAA/ ASD

FAA/ ASY

FAA/ AUA

FAA/ AVR

FAA/ AWR

FAA/ CAMI

FAA/ Technical Center

Flight Data Co.

GAMA

General Electric

Gulfstream Aerospace

Helicopter Assoc. Inter. (HAI)

Honeywell

Hughes

Jeppesen

Johns Hopkins Univ.

Litton/ APD

Litton/ PRC

Lockheed Martin

McDonnell Douglas

McDonnell Douglas Helicopter

MITRE Corporation

NARI

NASA/ ARC

NASA/ DRFC

NASA/ HQ

NASA/ JPL

NASA/ LaRC

NASA/ LeRC

NATA

NATCA

Natl. Inst. for Aviation Research

National Weather Service

NAVAIR

NBAA

NCAR

NOAA

North Carolina A&T Univ.

Northrop Grumman

Northwest Airlines

NRL

NTSB - Seattle Field Office

NTSB - Washington, DC Office

OFCM - Fed. Coord. for Metrlgy

Pratt & Whitney Aircraft Engines

Regional Airline Assoc.

Rockwell International

RTI

SAIC

SAMA

Sikorsky Aircraft

TASC

TechMatics, Inc.

Teledyne Cont.

UCLA

University of Illinois

Wichita State University

Williams International

Thank You!

**Doug Arbuckle, John Burks, Huey Carden, Mary Connors, Mike Durham,
Tom Edwards, Joe Elliott, George Finelli, Hugh Gray, Sandra Hart, HaeOk Lee,
Mike Lewis, Bob Luddy, Cynthia Null, Ralph A'Harrah, Bob Pearce,
Mark Potapczuk, Joel Sitz, Herb Schlickemaier, Carrie Walker**

Brightest & Best

Hard Working

A Model of Aerocentricity

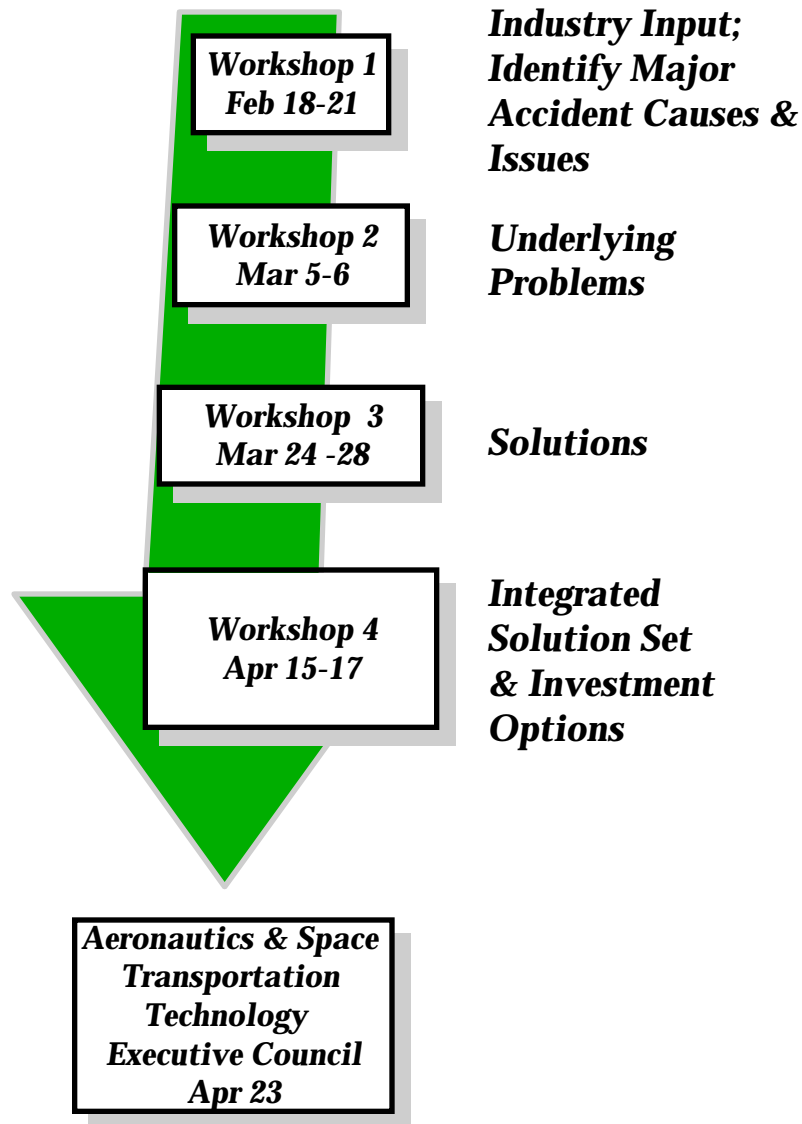
Focused on Mission

Cross Center/Agency Collaboration

Tough Decisions w/o Parochialism

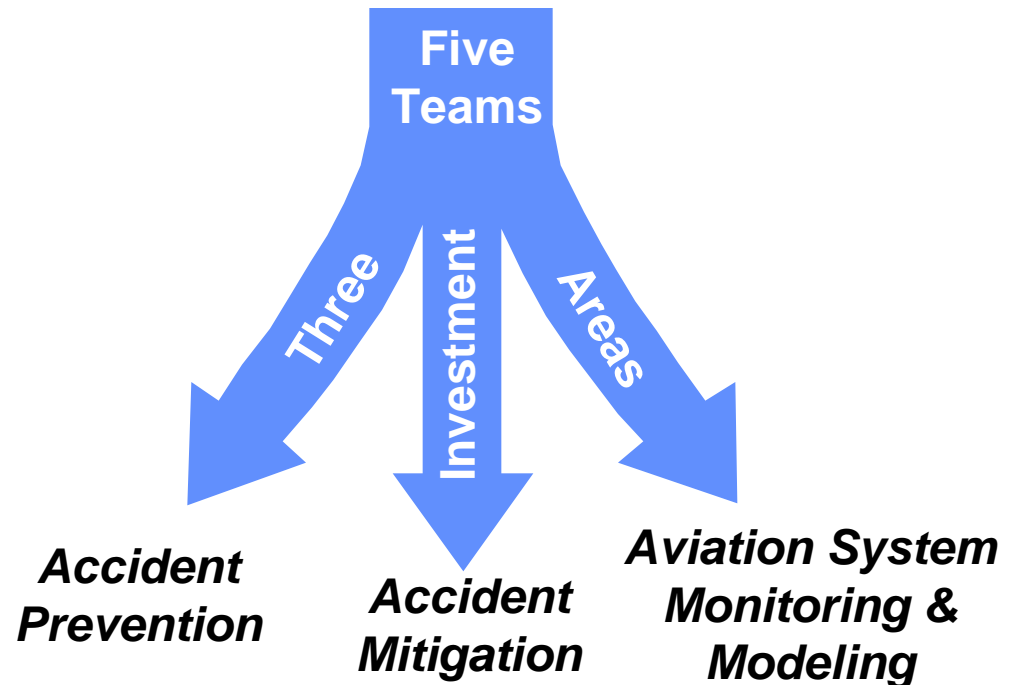
Accomplished Within Two Months What has Never Been Done Before!

NASA Aviation Safety Investment Strategy Team (ASIST) Process



Five ASIST Sub-Teams Formed:

- Human Error Consequences
- Weather
- Flight Critical Systems & Information Integrity
- Human Survivability
- Aviation System-wide Monitoring, Modeling & Simulation



NASA Aviation Safety Research Investment Strategy

Accident Prevention

Technology to Eliminate Accident Precursors

Weather Team
Human Error Team
Flight Critical Systems &
Information Integrity Team

Accident Mitigation

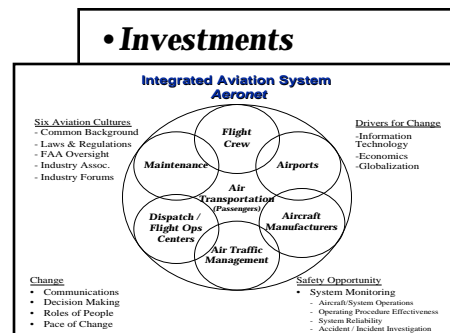
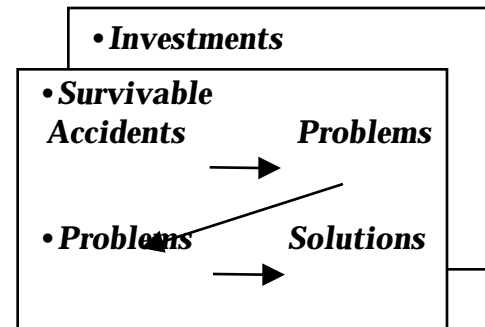
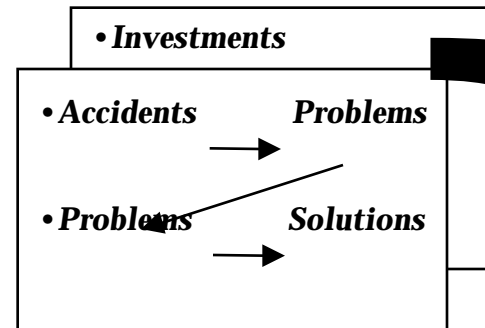
Decrease Fatalities of Survivable Accidents

Human Survivability Team

Aviation System Monitoring & Modeling

- System-Level Concepts for Improving Safety
- Identify Future Safety Issues Requiring Technology Development

Aviation System-wide Monitoring,
Modeling & Simulation Team



**Solution
List**

**Bold
Solutions**

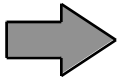
**Early
Impacts**

Criteria for NASA Investment

- **Contribution to Accident Rate Reduction**
- **Implementable**
- **No Duplication of Effort**
- **Within NASA's Mission**
- **Address Issues in Each Aviation Segment**
 - **Transport**
 - **General Aviation**
 - **Rotorcraft**

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Outline

- **Definitions/Scoping**
- **Accident Data to Issues**
- **Issues to Solution Structure**
- **Assessments of Current Aviation System Capability and R&D Focus**
- **5-Year Investments and Goals**
- **15-Year Investments and Visions**
- **Summary**

Team Definition/Scoping Notes

- **Weather:** Normal weather considerations + night, wake vortex, volcanic ash
- **Human Error Consequences:** Not all Human Factors; Not just pilots
- **Flight Critical Systems and Information Integrity:** All a/c systems, including propulsion, structure, avionics, etc., and air/ground links

Relationship of Accident Types to Human Error Problem Areas

Airline (Large jet transports)

	World-wide Fatal Accidents (Source: Boeing, p. 41)	U.S. Fatal Accidents (Source: Nall, p.10, modified per Volpe CFIT analysis)	U.S. Accidents (Source: NTSB reports)	"Best Judgement" Allocation of Accident Causes to Human Error Consequences Subteam Issue Areas		
	Large jets	GA	Rotorcraft			
ACCIDENT TYPE	ALL 1991-1995	pilot-related 1995	ALL 1989-1993	HUMAN	TASK	PERSONAL ENVIRONMENT
Loss of Cntrl in Flt	27%	22%	19%	.60 [B,C]	.40 [C,D,E,F,G]	
CFIT/Collision w/ wire/obj/gnd	29%	16%	10%	.20 [C]	.60 [B,C,D,E,F]	.20 [B]
Fire	2%			not applicable	not applicable	not applicable
Mid-Air	2%		1%	.20 [C]	.80 [B,D,E]	
Landing	12%	3%		.30 [C]	.60 [B,C,D,E,F]	.10 [B]
Ice/Snow	5%	24%		.30 [B,C]	.70 [B,C,D,E]	
Wind Shear	3%			.30 [B,C]	.70 [B,C,D,E]	
<i>Take-off/ climb</i>		13%				
<i>Approach</i>		9%				
<i>Go-around</i>		3%				
PILOT ERROR-misc			25%			
PILOT ERROR-power			7%			
PILOT ERROR (weather)			6%			
Systems/Hardware failure			18%			
Other	8%	7%	10%	?	?	?
Runway incursion	7%			.20 [C]	.80 [B,C,D,E,F,G]	
Fuel mgmnt	5%	3%	4%	.20 [C]	.20 [B,C,E]	.60 [B]
TOTAL	100%	100%	100%			

Accident Data-Driven Identification of FCSII Problems/Issues

		Transport (# of)		Contributing Factor to Accident
		All	Fatal	
Collisions	{	18	14	CFIT
		5	0	Ground Collision
		2	2	Incursion
		5	1	Mid-air
Loss of Control	{	4	0	FOD
		16	4	Loss of Control
Engines	{	19	2	Engine Fail
		3	0	Engine Fire
		3	1	Engine Separate
Landing Gear	{	26	0	Gear Failure
		3	0	Wheel Failure
		10	1	Tire Fail/Burst
Take-Off & Landing Incidents	{	1	0	Tail Strike
		2	2	Mistrim
		25	1	Land Hard
		10	2	Landed Short
		34	2	Off The End
		13	0	Off The Side
		1	1	Forced Landing
System Failure	{	2	2	Instrument Failure
		4	0	Hydraulic Failure
		2	2	Fuel Management
		2	0	No Pressurization
		4	0	Parts Lost
		1	1	Flt Mgmt Sys Fail
		2	2	Rudder
		1	1	Slat Extension
		1	1	Thrust Rev in Flt
Pilot	{	2	2	Pilot Error
		3	2	Pilot Error-Weather
		4	0	Pilot Error-Taxi
Weather	{	7	1	Weather
		3	3	Wing Icing
Other	{	21	3	Other & Unknown
		259	53	

Note: Data from McDonnell Douglas 1995 Accident Report, Time Period from 1991 to 1995

Accident Data Summary

Accident Rate Data (approx)									
G/A		Commuter		Transport		Rotorcraft			
Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal	Atmospheric/ Weather Hazard	
1	1	1	1	1	2	1	1	Ceiling & Visibility	
								Fog/Haze	
								Precipitation	
								Clouds	
								Night Ops	
3	2	2	2	2	3	2	2	Convection and Winds	
								Thunderstorms	
								Hail	
								Heavy Rain	
2	1	2	2				1	Winds	
		2		2				Wind Shear	
3	3	3	3	3	1	3	3	Turbulence	
								Convection	
								Terrain Induced	
								Jet Stream	
								Tropopause	
								Gravity Waves	
								Frontal	
2	3	1	2	1	3	2	2	Icing	
								In-Flight	
								Ground	
								Induction (Dew Point)	
3	3	3	3	3	3	3	3	Wake Vortex	
3	3	3	3	3	2*	3	3	Volcanic Ash	
3	3	3	3	2	3	3	3	Runway Contam.	
			1	Significant Contributor to Accidents					
			2	Moderate Contributor to Accidents					
			3	Minimal Contributor to Accidents					

- Weather is a factor in approximately 30% of aviation accidents
- In addition, the majority of “CFIT” and “Loss of Control” accidents can be considered “visibility-induced crew error”, where better weather information or pilot vision would have been a substantial mitigating factor.
- Differences between most important fatal accident factors and general accident causes for different aircraft classes.(both important)

Human Error Matrix

		Solution or Intervention						
<i>Human Error Issues</i>		Select & Training	Proced	Roles & Respons	Metrics & Models for Evaluation	System Design	New System or Tech	Sched
HUMAN								
Capabilities (neuromotor, etc)								
	Skill Proficiency							
	Performance Readiness							
	Cultural Factors							
TASK								
	Teamwork							
	Communications							
	Decision Making							
Human-Machine Interface & Interaction								
	Situation Awareness							
Task Allocation, Demand and Mgmt								
	Procedures							
PERSONAL ENVIRONMENT								
	Physical							
	Organizational culture							

FCSII Matrix

		Solution/Intervention Areas							
Flight Critical Systems and Information Integrity Issues			On-board Algorithms (e.g. control, health monitoring)	Actuating (incl. Hydraulics and Electric)			Interface, Comm., & Display	Design, Verification, Certification, Manufacture	
		Sensing			Maintenance & Inspection	Materials & Structures			CNS/ATM
	Airframe								
	Propulsion								
	Systems								
	Integration								
	Information Integrity								
	Air Traffic Control								

Weather Matrix

Accident Rate Data (approx)								Atmospheric/ Weather Hazard	Strategic Weather Information					Tactical Weather Information and Aircraft Systems		Weather Operations		
G/A		Commuter		Transport		Rotorcraft												
Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal											
1	1	1	1	1	2	1	1	Ceiling & Visibility										
								Fog/Haze										
								Precipitation										
								Clouds										
								Night Ops										
3	2	2	2	2	3	2	2	Convection and Winds										
								Thunderstorms										
								Hail										
								Heavy Rain										
2	1	2	2				1	Winds										
		2		2				Wind Shear										
3	3	3	3	3	1	3	3	Turbulence										
								Convection										
								Terrain Induced										
								Jet Stream										
								Tropopause										
								Gravity Waves										
								Frontal										
2	3	1	2	1	3	2	2	Icing										
								In-Flight										
								Ground										
								Induction (Dew Point)										
3	3	3	3	3	3	3	3	Wake Vortex										
3	3	3	3	3	2*	3	3	Volcanic Ash										
3	3	3	3	2	3	3	3	Runway Contam.										

1 Significant Contributor to Accidents
 2 Moderate Contributor to Accidents
 3 Minimal Contributor to Accidents

Weather Current Technology Assessment Matrix

Accident Rate Data (approx)								Current Wx Technology/ Systems Assessment	Strategic Weather Information					Tactical Weather Information and Aircraft Systems		Weather Operations		
G/A		Commuter		Transport		Rotorcraft			Sensing	Collection	Modeling and Forecasting	Product Generation	Data Dissemination	Sensors/ Systems	Weather Tolerant Aircraft Design	Simulation and Hazard Characterization	Crew/Dispatch /ATC Hazard Monitoring, Display, and Decision Support	Crew/Dispatch /ATC Training
Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal											
1	1	1	1	1	2	1	1	Ceiling & Visibility	2	2	1	2	1	2		3	1	2
								Fog/Haze	3	2	1	2	1	3		3	1	2
								Precipitation	2	2	1	2	1	2		3	1	2
								Clouds	3	3	3	3	3	2		3	3	2
								Night Ops	3	3	3	3	3	2	3	3	2	
3	2	2	2	2	3	2	2	Convection and Winds										
								Thunderstorms	2	2	2	2	1	3	2	3	1	2
								Hail	2	3	1	1	1	2	2	3	1	2
								Heavy Rain	3	2	2	2	1	2	2	3	1	2
2	1	2	2				1	Winds	2	2	2	2	1	1	2	3	1	2
		2		2				Wind Shear	2	2	1	3	2	2	2	3	2	2
3	3	3	3	3	1	3	3	Turbulence										
								Convection	1	1	1	2	1	1	2	1	1	2
								Terrain Induced	1	1	1	1	1	2	1	1	2	
								Jet Stream	1	1	1	1	1	2	1	1	2	
								Tropopause	1	1	1	1	1	2	1	1	2	
								Gravity Waves	1	1	1	1	1	2	1	1	2	
								Frontal	2	2	2	2	1	2	1	1	2	
2	3	1	2	1	3	2	2	Icing										
								In-Flight	1	1	1	1	1	2	2	1	2	
								Ground	2	2	2	2	2	1	2	1	2	
								Carburetor	3	3	3	2	1	2	3	2	2	
3	3	3	3	3	3	3	3	Wake Vortex	1	1	1	1	1	2	1	1	2	
3	3	3	3	3	2*	3	3	Volcanic Ash	2	2	2	3	1	1	1	1	2	
3	3	3	3	2	3	3	3	Runway Contam.	2	3	1	2	1	2	1	1	2	

1

2

3

1

2

3

1

 Significant Contributor to Accidents

2

 Moderate Contributor to Accidents

3

 Minimal Contributor to Accidents

1

 Minimal or No Current Capability

2

 Current Capability/Systems Partially Capable

3

 Current Capability/Systems Reasonably Adequate

Not Applicable

3

1

 Minimal or No Current Capability

2

3

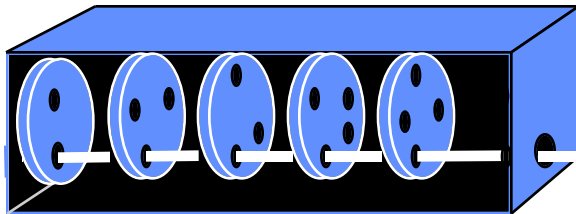
Weather Current R & D Assessment Matrix

Accident Rate Data (approx)								Current Weather R&D Assessment	Strategic Weather Information					Tactical Weather Information and Aircraft Systems		Weather Operations			
G/A		Commuter		Transport		Rotorcraft			Sensing	Collection	Modeling and Forecasting	Product Generation	Data Dissemination	Sensors/ Systems	Weather Tolerant Aircraft Design	Simulation and Hazard Characterization	Crew/Dispatch /ATC Hazard Monitoring, Display, and Decision Support	Crew/Dispatch /ATC Training	
Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal												
1	1	1	1	1	2	1	1		Ceiling & Visibility	2	1	1	2	2	2		1	1	1
									Fog/Haze	2	1	1	2	2	2		1	1	1
									Precipitation	3	2	1	2	2	2		1	1	1
									Clouds	2	2	2	2	2	2		1	1	1
									Night Ops	2	2	2	2	2	2				
3	2	2	2	2	3	2	2		Convection and Winds										
									Thunderstorms	3	2	2	2	2	1	1	2	1	1
								Hail	2	2	2	1	2	2	1	2	1	1	
								Heavy Rain	3	2	2	2	2	1	1	1	1	1	
2	1	2	2				1	Winds	1	1	2	2	2	2	1	1	1	1	
		2		2				Wind Shear	3	2	1	1	2	2	1	1	1	1	
3	3	3	3	3	1	3	3	Turbulence											
								Convection	1	2	2	2	2	1	1	2	1	1	
								Terrain Induced	3	2	2	2	2	1	1	2	1	1	
								Jet Stream	1	2	2	2	2	1	1	2	1	1	
								Tropopause	1	2	2	2	2	1	1	2	1	1	
								Gravity Waves	1	2	1	1	2	1	1	2	1	1	
								Frontal	1	2	2	1	2	1	1	2	1	1	
2	3	1	2	1	3	2	2	Icing											
								In-Flight	2	2	2	2	1	2	2	2	1	1	
								Ground	2	2	2	2	1	2	1	2	1	1	
								Carburetor	1	2	2	1	1	1	1	1	1	1	
3	3	3	3	3	3	3	3	Wake Vortex	2	1	2	2	2	1	1	1	2	1	
3	3	3	3	3	2*	3	3	Volcanic Ash	1	1	2	1	1	1	1	1	1	1	
3	3	3	3	2	3	3	3	Runway Contam.	2	2	2	1	1	2	1	2	1	1	

1 Significant Contributor to Accidents
 2 Moderate Contributor to Accidents
 3 Minimal Contributor to Accidents

1 Minimal Or No R&D Efforts Underway or Funded
 2 Moderate R&D Efforts Underway or Funded
 3 Significant R&D Efforts Underway or Funded
 Not Applicable

The Accident Chain Progression Box



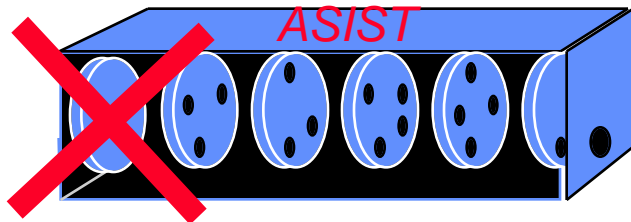
Challenge: Develop solutions to eliminate entire categories of accidents, not single cases



Strategy #1: “Add a solid disk to block failures”



Strategy #2: “General Principles to Design/Operate for Fewer and Smaller holes”



Strategy #3: “Attack the hole on the left”

Weather Subteam 5-Year Investment Matrix

Accident Rate Data (approx)								5 Year Weather Project Areas	Strategic Weather Information					Tactical Weather Information and Aircraft Systems		Weather Operations		
G/A		Commuter		Transport		Rotorcraft			Sensing	Collection	Modeling and Forecasting	Product Generation	Data Dissemination	Sensors/ Systems	Weather Tolerant Aircraft Design	Simulation and Hazard Characterization	Crew/Dispatch /ATC Hazard Monitoring, Display, and Decision Support	Crew/Dispatch /ATC Training
Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal											
1	1	1	1	1	2	1	1											
								Ceiling & Visibility										
								Fog/Haze										
								Precipitation										
								Clouds										
								Night Ops										
3	2	2	2	2	2	3	2	2	Convection and Winds									
								Thunderstorms										
								Hail										
2	1	2	2				1	Heavy Rain										
		2		2				Winds										
3	3	3	3	3	1	3	3	Wind Shear										
								Turbulence										
								Convection										
								Terrain Induced										
								Jet Stream										
								Tropopause										
								Gravity Waves										
2	3	1	2	1	3	2	2	Frontal										
								Icing										
								In-Flight										
								Ground										
								Carburetor										
3	3	3	3	3	3	3	3	Wake Vortex										
3	3	3	3	3	2	3	3	Volcanic Ash										
3	3	3	3	2	3	3	3	Runway Contam.										

1

2

3

Significant Contributor to Accidents

Moderate Contributor to Accidents

Minimal Contributor to Accidents

A

B

C

First Priority Investment Areas

Second Priority Investment Areas

Third Priority Investment Areas

GA Prime Focus Investment Area

Transport Prime Focus Investment Area

Both GA and Transport Investment Area

1 Significant Contributor to Accidents
 2 Moderate Contributor to Accidents
 3 Minimal Contributor to Accidents

"A" First Priority Investment Areas
 "B" Second Priority Investment Areas
 "C" Third Priority Investment Areas

GA Prime Focus Investment Area
 Transport Prime Focus Investment Area
 Both GA and Transport Investment Area

Human Error Consequences Subteam 5-Year Investment Matrix

<i>Human Error 5-Year Investment Areas</i>		Solution or Intervention						
		Select & Training	Proced	Roles & Respons	Metrics & Models for Evaluation	System Design	New System or Tech	Sched
HUMAN								
	Capabilities (neuromotor, etc)	V-1						
	Skill Proficiency							
	Performance Readiness				V-3			V-5
	Cultural Factors					V-7		
TASK								
	Teamwork	M-1	M-2		A-1			
	Communications							
	Decision Making	V-2					A/G-2	
	Human-Machine Interface & Interaction				V-8			
	Situation Awareness	R-1					R-2	
	Task Allocation, Demand and Mgmt							
	Procedures		M-3			A-3		
PERSONAL ENVIRONMENT								
	Physical							
	Organizational culture		A-4					



Airline/GA/Maint



Rotorcraft



ALL Vehicles

A-1 Design to support Teamwork

A-3 Procedures Design Methods

A-4 Organizational Culture for Safety

A/G- Flight Deck Design and Integration

M-1 Maintenance Training (augment FAA ongoing pgm)

M-2 Maintenance Teamwork Procedures & Roles/Responsibilities

M-3 Maintenance Task Procedures

R-1/ Rotorcraft-specific Procedures and Training

R-2 Rotorcraft-specific pilot aiding systems

V-1 HUMAN Selection & Training

V-2/2* TASK Selection & Training

V-3 HUMAN/TASK Metrics & Models for Evaluation

V-4 Skill Proficiency

V-5 Fatigue and Circadian Disruption Impacts

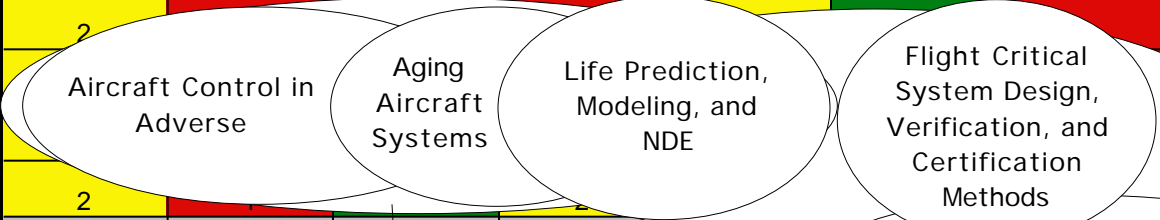
V-6 Design to support Performance Readiness

V-7 Cultural Factors

V-8/8* Human/Automation Design Principles and Guidelines

Flight Critical Systems & Information Integrity

Subteam 5-Year Investment Matrix

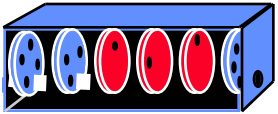
<i>FCSII 5-Year Investment Areas</i>	Solution/Intervention Areas								
Issues	Sensing	On-board Algorithms (e.g. control, health monitoring)	Actuating (incl. Hydraulics and Electric)	Maintenance & Inspection	Materials & Structures	Interface, Comm., & Display	Design, Verification, Certification, Manufacture	CNS/ATM	
Airframe	2							Technology Integration, Validation, and Effective Transition	
Propulsion									
Systems									
Integration	2								
Information Integrity		Health & Usage Monitoring Systems for Rotorcraft & Aircraft				Design/Assessment of Data Link			
Air Traffic Control						NAS Tools for Safety & Security			

1	High Need
2	Medium Need
3	Low or No Need
	Not Applicable

Potential 5-Year Investment:

- 5.1 Aircraft Control in Adverse Conditions
- 5.2 Life Prediction, Modeling, and NDE
- 5.3 Aging Aircraft Systems
- 5.4 Flight Critical System Design, Verification, and Certification Methods
- 5.5 Technology Integration, Validation, and Effective Transition
- 5.6 Design & Safety/Risk Assessment of Data Link Technologies
- 5.7 NAS Tools for Safety & Security
- 5.8 Health & Usage Monitoring Systems for Rotorcraft & Aircraft

Example 5-Year Goals/Early Starts



Metrics that allow system designs, procedures, and training programs to be evaluated for human error susceptibility

- Near-term training opportunities (e.g., weather, FMS, etc.)
- Implement recommended strategies to address fatigue and circadian rhythm effects on human performance
- Identify improvements in airplane mechanic teamwork, communications, and procedures for increased safety and maintenance efficiency



Initial definition of human/automation design methodology

- Identify potential retrofit flight deck system integration as well as new flight deck design concepts



Develop system technologies to prevent accidents due to unexpected failures or damage that affect stability and control



Develop modeling, prediction, and inspection tools to assure safe operation with extended life airframe and engine materials, structures, and systems



Develop techniques and technologies for real-time, in-flight dissemination of weather products nationwide

- Immediate dissemination/display techniques for current weather products

Human Error Consequences Subteam 15-Year Investment Matrix

Human Error 15-Year Investment Areas	Solution or Intervention						
	Select & Training	Proced	Roles & Respons	Metrics & Models for Evaluation	System Design	New System or Tech	Sched
HUMAN							
Capabilities (neuromotor, etc)	V-1						
Skill Proficiency			V-4				
Performance Readiness				V-3	V-6		
Cultural Factors					V-7		
TASK							
Teamwork		M-2					
Communications	V-2*					A/G-2*	
Decision Making							
Human-Machine Interface & Interaction							
Situation Awareness							
Task Allocation, Demand and Mgmt							
Procedures							
PERSONAL ENVIRONMENT							
Physical							
Organizational culture		A-4					

A, G, M

Airline/GA/Maint

R

Rotorcraft

V

ALL Vehicles

A-4 Organizational Culture for Safety

A/G- Flight Deck Design and Integration

M-2 Maintenance Teamwork Procedures & Roles/Responsibilities

R-1/ Rotorcraft-specific Procedures and Training

R-2 Rotorcraft-specific pilot aiding systems

V-1 HUMAN Selection & Training

V-2/2*

V-3 HUMAN/TASK Metrics & Models for Evaluation

V-4 Skill Proficiency

V-6 Design to support Performance Readiness

V-7 Cultural Factors

V-8/8* Human/Automation Design Principles and Guidelines

Flight Critical Systems & Information Integrity Subteam 15-Year Investment Matrix

<i>FCSII 15-Year Investment Areas</i>	Solution/Intervention Areas							
Issues	Sensing	On-board Algorithms (e.g. control, health monitoring)	Actuating (incl. Hydraulics and Electric)	Maintenance & Inspection	Materials & Structures	Interface, Comm., & Display	Design, Verification, Certification, Manufacture	CNS/ATM
Airframe	2							
Propulsion								
Systems								
Integration	2							
Information Integrity								
Air Traffic Control								

1	High Need
2	Medium Need
3	Low or No Need
	Not Applicable

Potential 15-Year Investments:-

- 15.1 Design Techniques for High-Integrity Complex Digital Systems
- 15.2 Structural Configurations and Aging Airframes/Engines
- 15.3 Fault and Damage Tolerance
- 15.4 Health Monitoring and Fault Diagnostics
- 15.5 Advanced Containment Concepts for Engine Failure
- 15.6 Technology Integration, Validation, and Effective Transition
- 15.7 Safety & Information Security of Aircraft Operations in Future NAS

Weather Subteam 15-Year Investment Matrix

Accident Rate Data (approx)								15 Year Weather Project Areas	Strategic Weather Information					Tactical Weather Information and Aircraft Systems		Weather Operations		
G/A		Commuter		Transport		Rotorcraft			Sensing	Collection	Modeling and Forecasting	Product Generation	Data Dissemination	Sensors/ Systems	Weather Tolerant Aircraft Design	Simulation and Hazard Characterization	Crew/Dispatch /ATC Hazard Monitoring, Display, and Decision Support	Crew/Dispatch /ATC Training
Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal	Fatal	Non-Fatal											
1	1	1	1	1	2	1	1	Ceiling & Visibility										
								Fog/Haze										
								Precipitation										
								Clouds										
								Night Ops										
3	2	2	2	2	3	2	2	Convection and Winds										
								Thunderstorms										
								Hail										
								Heavy Rain										
2	1	2	2				1	Winds										
		2		2				Wind Shear										
3	3	3	3	3	1	3	3	Turbulence										
								Convection										
								Terrain Induced										
								Jet Stream										
								Tropopause										
								Gravity Waves										
								Frontal										
2	3	1	2	1	3	2	2	Icing										
								In-Flight										
								Ground										
								Carburetor										
3	3	3	3	3	3	3	3	Wake Vortex										
3	3	3	3	3	2*	3	3	Volcanic Ash										
3	3	3	3	2	3	3	3	Runway Contam.										

1

2

3

Significant Contributor to Accidents

Moderate Contributor to Accidents

Minimal Contributor to Accidents

"A"

"B"

"C"

First Priority Investment Areas

Second Priority Investment Areas

Third Priority Investment Areas

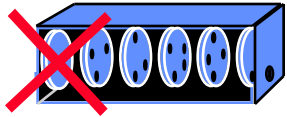
Investment Area

1 Significant Contributor to Accidents
 2 Moderate Contributor to Accidents
 3 Minimal Contributor to Accidents

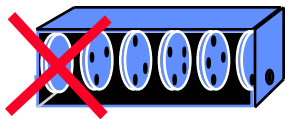
"A" First Priority Investment Areas
 "B" Second Priority Investment Areas
 "C" Third Priority Investment Areas

Investment Area

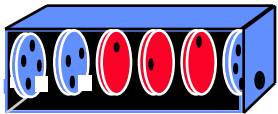
15-Year Visions



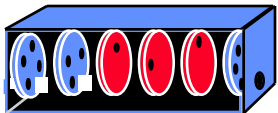
Visibility-induced errors eliminated for all aircraft through the cost-effective use of synthetic/enhanced vision displays, worldwide terrain data bases, and GPS navigation



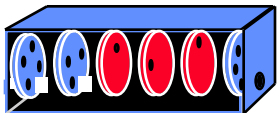
Accurate, high resolution international nowcasts and forecasts, dissemination, displays, and crew aids provided to allow safe and informed weather-related operational decisions



Common weather information/data parity/situational awareness for integrated aircraft/ATC/operations decisions



Models/Metrics available that accurately predict human error susceptibility of system designs, procedures, and training programs



“Training to Proficiency” implemented across a wide range of training systems (PC’s to full motion flight simulators)



Lightweight systems designed to contain engine failures



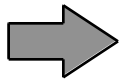
Technologies installed for tactical, real-time aircraft control and management in failure, damage, and upset conditions

Summary

- Existing, augmented, and new R&D project areas identified
- Good cross-cut of issues/investments for all a/c types
 - Sandy Hart, Mike Durham efforts
- Many “15-year” investment areas to start in first 5 years
- Integrated (HE, FC, Wx) solution implementations anticipated
- Significant economic payoffs of numerous proposals (low vis operations, optimal wx/wind routing, reduced maintenance costs, others)
- Good (though not unanimous) Government/Industry consensus on priorities - still getting some feedback
- Dramatic safety improvements possible by eliminating whole classes of accidents with strategic technology/design solutions

ASIST EC Presentation Agenda

1. Safety Research: *WHY* (C. Huettner - 5 min)
2. Systems Approach to Improving Safety (C. Huettner - 10 min)
3. ASIST Process (C. Huettner - 10 min)
4. Safety Research: *WHAT* (40 min)
 - Accident Prevention (Mike Lewis - 20 min)
 - Accident Mitigation (Huey Carden - 5 min)
 - Aviation System-wide Monitoring, Modeling & Simulation (Tom Edwards - 15 min)
5. Recommendations (C. Huettner - 30 min)
6. Issues (C. Huettner - 10 min)



Accident Mitigation -- Human Survivability (HS)

Prioritization Of Investment Areas Across The Major Four Human Survivability Issues

1. Fire Prevention (Pre/Post Incident)

- **Crash Resistant Fuel Systems** • **Fire Safe Fuels/Systems**
- **Fire Detection/Suppression** • **Fire Safe Materials**

2. Systems Approach To Crashworthiness

- **Analytical Modeling** • **Metal/Composite Structures**
- **Design Criteria/Guidelines** • **Biomechanics**

3. Systems Approach To Evacuation

- **Modeling** • **Procedures/Training** • **Equipment**
- **Exit/Slide Design Criteria** • **Guidelines**

4. (Occupant Protection) Maintaining Physiological Stability

- **Alternate O₂ Generation** • **Protection from Contaminants**
- **Hypoxia**

Human Survivability (HS) Proposed Investments



Accident Mitigation -- Human Survivability (HS)

Challenges/Objective of HS Investments

- **Challenges/Objective of Fire Investment :**
To Identify, Support, and Develop Fire Prevention, Detection, and Suppression Concepts That Can Minimize Fire Hazards in Crashes and In-Flight Incidents.
- **Challenges/Objective of Crashworthiness Investment:**
To Develop A Systems Approach To Crashworthiness Design That Includes Validated Analysis Methodology, New Structural Concepts And Materials, Safer Cabin Interiors Design, Advanced Restraint Equipment, Design And Injury Criteria To Enhance Crash Safety.
- **Challenges/Objective of Evacuation Investment ::**
To Develop A Systems Approach For Evacuation That Includes Analysis/Simulation Methodology, New Procedures ,Training, Equipment, And Design Criteria Which Can Enhance And Provide Means For More Timely Evacuation During Fire In Aircraft Accidents.
- **Challenges/Objective of Occupant Protection Investment:**
To Develop Detection/Warning Means, New Procedures ,Training, And Equipment Which Can Provide Occupant Protection From Fire Related Hazards And Thus Provide Additional Evacuation Time.

All the Challenges/Objectives Are Aimed At Mitigation/Reduction of Fatalities and Serious Injuries In Current As Well As New Aircraft Configurations.

5-Year Early Impact In Accident Mitigation Through Human Survivability (HS)

Early Availability (For Retrofit Into Current Fleet) Of :

- **Improved Seats**
- **Advanced Restraints, and**
- **Supplemental Safety Devices (Airbags)**

Significance :

- **Enhanced Cockpit/Cabin Safety**
- **Measurable Improvements In Reduced Fatalities
And Serious Injuries During Impact Phase
Of Accidents**

15-Year Vision -- Taking A Systems Approach To Design & Why :

Crashworthiness

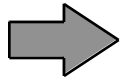
- **Significant Interactions Exist Between:**
 - Occupant Response
 - Seat Response
 - Restraint System Performance
 - Airframe Response
 - Impact Surface (b.c.)
 - Flight Conditions at Impact (i.c.)
- **Critical Needs:**
 - Injury Criteria
 - Component Performance
 - Simulation Tools (Integration)

Evacuation

- **Need to Consider All Aspects of Evacuation**
 - Equipment
 - Procedures
 - Training
 - Dependencies Between Equipments & Humans
- **Permits Evacuation Considerations Early in the Design Cycle for New and Derivative Aircraft**
- **Proposed New Designs (Multi-aisle, Multi-deck Aircraft, i.e. Blended Wing) Will Present Evacuation Design Challenges Not Confronted With Contemporary Designs**

ASIST EC Presentation Agenda

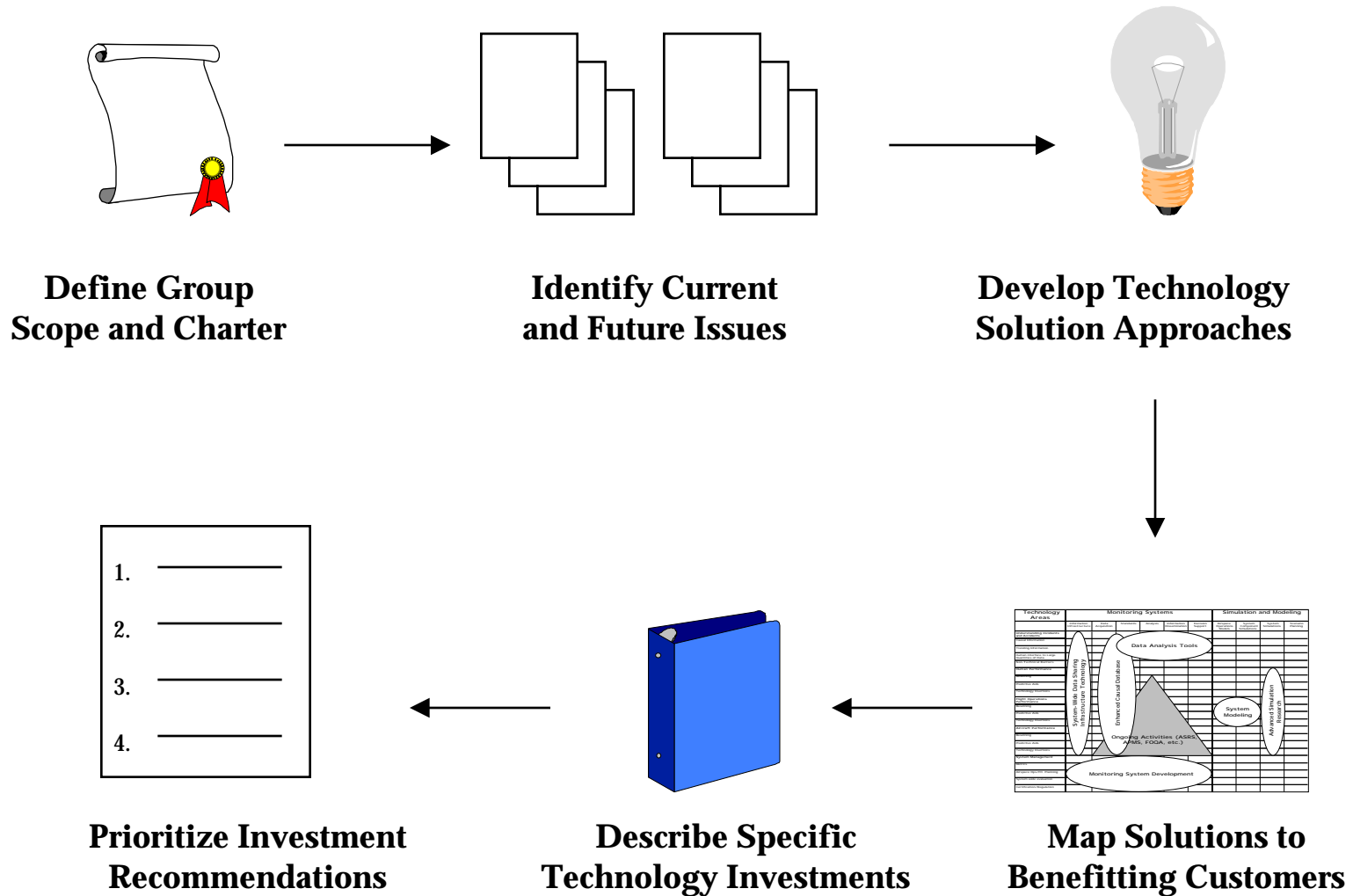
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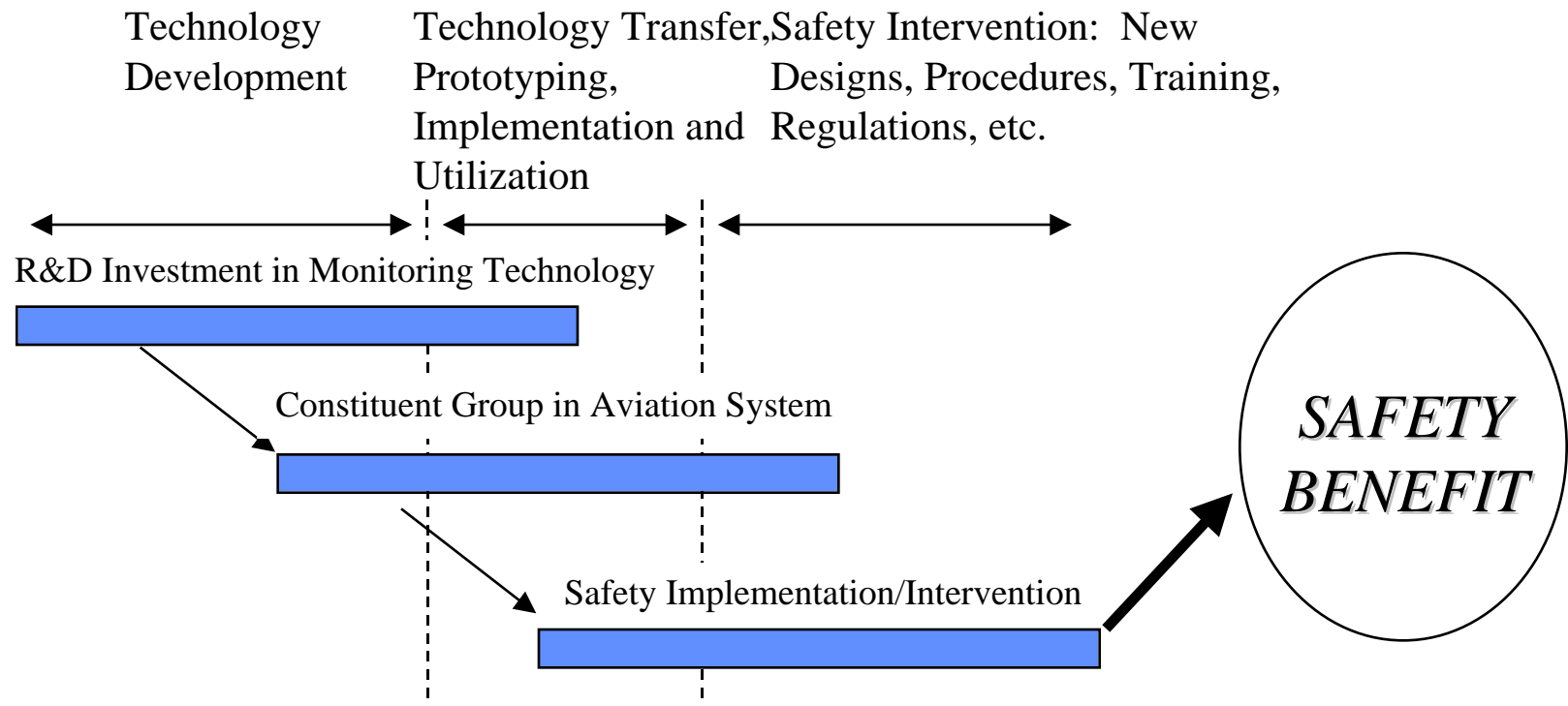
Background

- **System-wide monitoring**
 - Near-real-time acquisition, analysis, and dissemination of pertinent safety information
 - » Information sources: aircraft location, velocity, flight plans; flight crew decisions; weather; ground crew decisions; maintenance crew actions; aircraft maintenance records; operational decisions; threats/hostile action information; rules, procedures, etc.; aircraft performance information
 - » Analysis: Hazard identification; system health monitoring; decision support; scheduling support; performance measurement
 - » Dissemination: Passive or active delivery of data, information, and analysis to concerned parties in a meaningful time frame
- **Simulation**
 - Simulation duplicates, in some limited sense, a system to capture its critical characteristics
 - Simulation addresses system components or an entire system to: assess system performance in support of safety goals; explore and evaluate modifications to system to enhance safety, security, capacity & efficiency
- **Modeling**
 - Models are approximations to the behavior of a system developed through theoretical development and analysis of existing data
 - Models are used to develop simulation capabilities and to aid in the diagnosis of monitoring functions

Process



Defining the Connection between Monitoring and Safety



Five-Year Investment Objectives

- **Analyze existing accident and incident data for causal factors**
 - data analysis tools
 - technical support for FOQA programs
 - detailed studies of existing databases
- **Define, and create access to, additional data sources needed for detailed causal analysis**
 - identify new data sources and provide technology to access them
 - define standards, and formats for new “causal factor” databases
- **Develop high-fidelity integrated system simulation capability**
- **Develop meaningful safety metrics**
 - trend and pattern analysis
 - cost/benefit analysis of technology alternatives
- **Assess program content vs. current and future problem areas**
 - baselining current operations
 - tracking program performance
 - identifying emerging/unaddressed needs

Five-Year Investment Plan Matrix

Technology Areas	Monitoring Systems						Simulation and Modeling		
	Information Infrastructure	Data Acquisition	Standards	Analysis	Information Dissemination	Decision Support	Airspace Operations Models	System Component Simulations	System Simulations
Safety Application									
Understanding Incidents and Accidents	Data Sharing Technology	Accident/Incident Causal Database	Data Analysis Tools						
Causal Information									
Trending Information									
Human interface to Large Quantities of Data									
Non-Technical Barriers									
Human Performance									
Baselining									
Predictive Aids									
Technology Insertions									
Flight Operations Performance							High-Fidelity System Wide Modeling		System-Wide Simulation Research
Baselining									
Predictive Aids									
Technology Insertions									
Aircraft Performance									
Baselining									
Predictive Aids									
Technology Insertions									
System Management									
Metrics	Safety Data Studies and Technology								
Airspace Ops/Flt. Planning									
System-wide evaluation									
Certification/Regulation									

Fifteen-Year Investment Objectives

- **Enable rapid, comprehensive analysis and simulation of accidents and incidents and dissemination of safety information**
 - collect and assemble pertinent accident/incident data
 - search databases for related events
 - simulate conditions leading to incident
 - rapidly disseminate resultant safety information
- **Provide technology for secure, high-bandwidth communications for aviation safety information**
 - wireless IP networks for two-way, air-to-ground communication
 - satellite network technology and system design/development
- **Establish data- and information-sharing framework for uninhibited exchange of safety data among airlines, manufacturers, etc.**
 - data security and de-identification tools
 - standards, protocols, and formats
 - integration and dissemination of safety information
- **Establish global, real-time safety monitoring capability**
 - track safety metrics
 - identify emerging safety issues
- **Develop intelligent aids for aviation system management**
 - scenario planning
 - technology insertion
 - interventions
 - decision support

Fifteen-Year Investment Plan Matrix

Technology Areas	Monitoring Systems						Simulation and Modeling		
	Information Infrastructure	Data Acquisition	Standards	Analysis	Information Dissemination	Decision Support	Airspace Operations Models	System Component Simulations	System Simulations
Safety Application									
Understanding Incidents and Accidents	Rapid Response Accident/Incident Analysis and Simulation								
Causal Information									
Trending Information									
Human interface to Large Quantities of Data									
Non-Technical Barriers									
Human Performance									
Baselining									
Predictive Aids									
Technology Insertions									
Flight Operations Performance									
Baselining									
Predictive Aids									
Technology Insertions									
Aircraft Performance									
Baselining									
Predictive Aids									
Technology Insertions									
System Management									
Metrics									
Airspace Ops/Flt. Planning	Aviation System Safety Monitoring						Strategic System Management Aids		
System-wide evaluation									
Certification/Regulation									

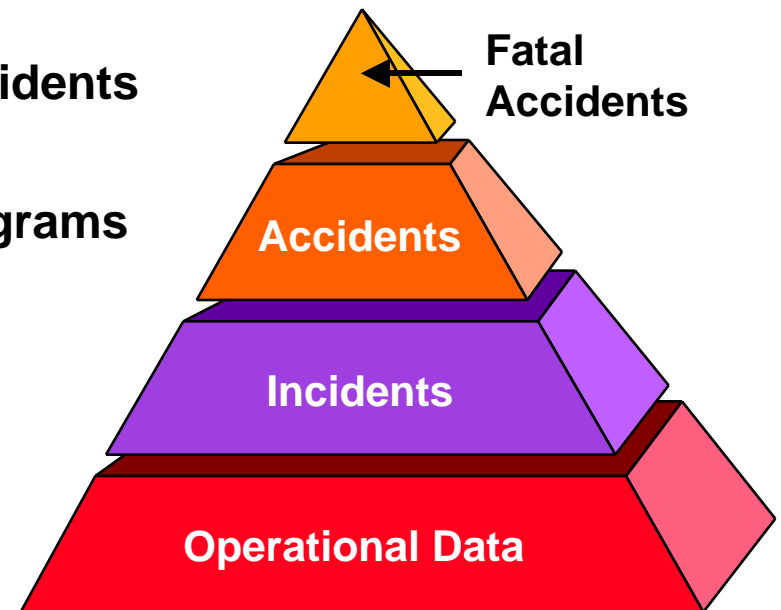
Near-Term Safety Payoffs: Safety Data Studies and Technology

Objectives:

- develop tools and techniques for safety data analysis
- perform detailed studies of existing databases
- provide tools for airline FOQA programs

Safety Benefits:

- correlation between incidents and accidents
- safety metrics and data requirements
- more successful corporate safety programs



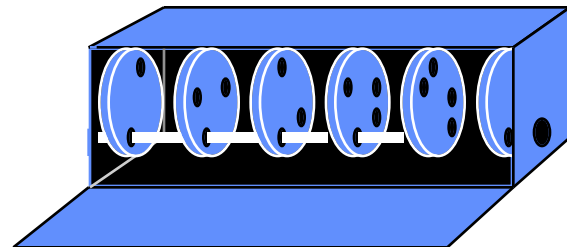
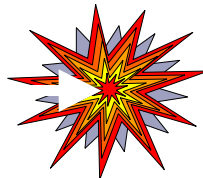
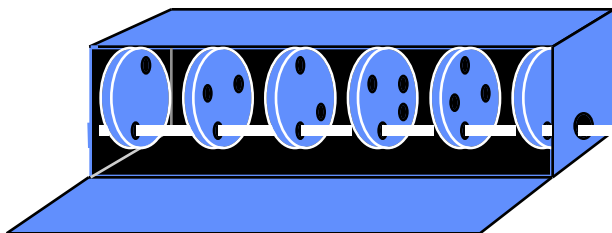
Near-Term Safety Payoffs: Accident/Incident Causal Database

Objectives:

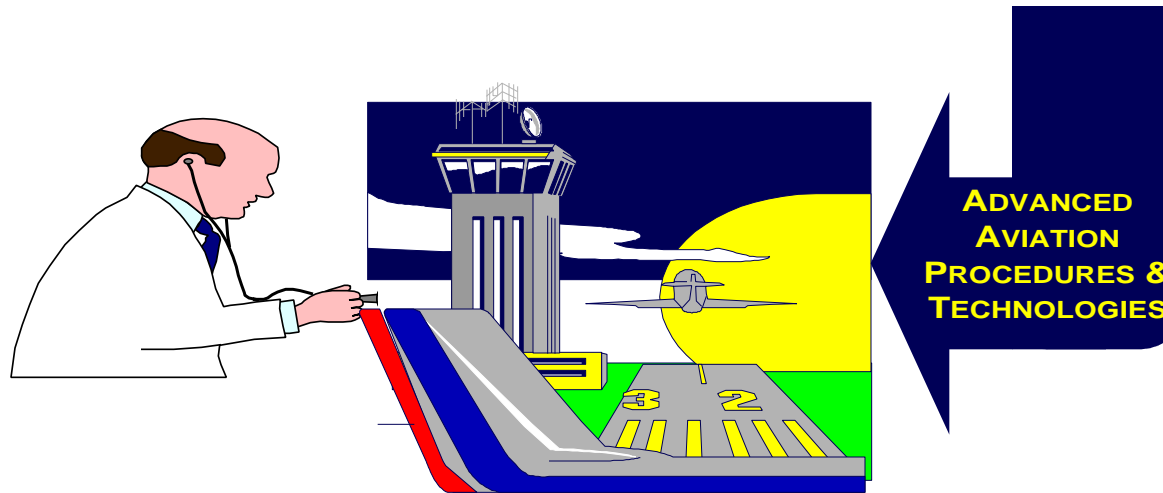
- identify additional data requirements for detailed causal analysis
- develop technologies required to access and disseminate new data sources
- analyze data to build more complete causal chains for incidents and accidents

Safety Benefits:

- better understanding of root causes of safety incidents
- more effective safety interventions
- develop risk assessment techniques



Revolutionary, High-Payoff R&D: Aviation System Safety Monitoring



Objectives:

- Real-time data acquisition and analysis
- Trend identification and pattern recognition
- Decision support for safety interventions

Safety Benefits:

- Early identification of emerging safety issues
- Rapid, effective decision-making
- Solve the problem before an accident occurs

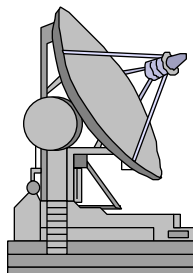
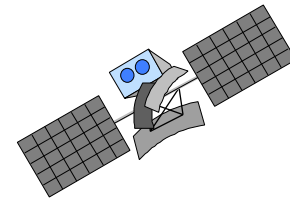
Revolutionary, High-Payoff R&D: Next-Generation Communications Technology

Objectives:

- develop technology for high-bandwidth, two-way communications between aircraft and ground
- provide for secure, reliable transmissions

Safety Benefits:

- real-time monitoring of safety data
- distributed decision-making



Summary

- **Information Technology is an unexploited approach to achieve national safety goals**
- **Many opportunities exist for both near-term impacts and long-term benefits**
- **Monitoring capabilities will ensure the relevance and measure the impact of the Safety Program**
- **Universal support for the goals outlined in this report**

ASIST EC Presentation Agenda

1. Safety Research: *WHY* (C. Huettner - 5 min)
2. Systems Approach to Improving Safety (C. Huettner - 10 min)
3. ASIST Process (C. Huettner - 10 min)
4. Safety Research: *WHAT* (40 min)
 - Accident Prevention (Mike Lewis - 20 min)
 - Accident Mitigation (Huey Carden - 5 min)
 - Aviation System-wide Monitoring, Modeling & Simulation (Tom Edwards - 15 min)
- ➡ 5. Recommendations (C. Huettner - 30 min)
6. Issues (C. Huettner - 10 min)

Accident Prevention Solutions

Aviation System Monitoring & Modeling



*Five Fold
Reduction
in the
Accident Rate
in 10 Years* 



Basis for Investment Recommendations

- **Developed with Industry**
- **Full Cost ROM estimates (\$, WY)**
- **Prioritized**
- **Current Safety Column Investments OK**
 - Detailed planning needed to determine exact relationships of ASIST planned and current programs
- **Initiatives Through “Gray Areas” Targeted for Planning**
 - Potential overlaps with current programs & phasing opportunities identified during detailed planning may allow for >\$500M investment to begin within the initial 5 years

Accident Prevention Investment Areas

Cumulative			Cumulative		
Category	Dollars Million	Dollars Million	Category	Dollars Million	Dollars Million
1 Digital Weather Product Dissemination	\$17	\$17	23 Turbulence Hazard Solutions	\$15	\$486
2 Human/Task Metrics & Models for Evaluation	\$35	\$52	24 Health Monitoring & Fault Diagnostics	\$12	\$498
3 Human/ Automation Design Principles and Guidelines	\$25	\$77	25 Tactical Weather Sensors/ Systems	\$11	\$509
4 Aircraft Control in Adverse Conditions	\$30	\$107	26 Cultural Factors	\$7	\$516
5 Crew/ Dispatch/ Wx Monitoring Presentation & Decision Making	\$29	\$136	27 Fatigue and Circadian Disruption Impacts	\$16	\$532
6 Task Selection and Training	\$19	\$155	28 Fault & Damage Tolerance	\$12	\$544
7 Flight Deck Design and Integration	\$30	\$185	29 Human Selection & Training	\$12	\$556
8 Icing Hazard Solutions	\$35	\$220	30 Design Techniques for High-Integrity Complex Digital Systems	\$12	\$568
9 Advanced Vision and Sensor Technology	\$10	\$230	31 Rotorcraft-specific Procedures and Training	\$18	\$586
10 Advanced Containment Concepts for Engine Failure	\$25	\$255	32 Structural Configurations and Aging Airframes/Engines	\$6	\$592
11 Life Prediction, Modeling, & NDE	\$30	\$285	33 Organizational Culture for Safety	\$9	\$601
12 Skill Proficiency	\$24	\$309	34 Safety & information security of flight operations in future NAS		\$601
13 Advanced Weather Products	\$20	\$329	35 Wake Vortex Hazard Avoidance	\$5	\$606
14 Design, Verification, & Certification Methods for Flight Critical Systems	\$25	\$354	36 Procedures Design Methods	\$6	\$612
15 FCSII Technology Integration, Validation, & Effective Transition	\$30	\$384	37 Design to support Teamwork	\$9	\$621
16 Design & Safety/Risk Assessment of Data Link Technologies	\$12	\$396	38 Weather Hazard Characterization	\$5	\$626
17 Rotorcraft-specific Pilot Aiding Systems	\$18	\$414	39 Cowl Fire Monitoring/Suppressant Techniques in Post-Halon Era	\$6	\$632
18 Aging Aircraft Systems	\$6	\$420	40 Maintenance Training	\$3	\$635
19 Maintenance Teamwork Procedures & Roles/Responsibilities	\$13	\$433	41 Runway Contamination	\$5	\$640
20 NAS Tools for Safety & Security	\$12	\$445	42 Maintenance Task Procedures	\$18	\$658
21 Advanced Aviation Meteorology	\$20	\$465	43 Design to support Performance Readiness	\$13	\$671
22 Health & Usage Monitoring Systems	\$6	\$471			

Accident Mitigation Investment Areas

- | | |
|--|--------------|
| 1. Fire Prevention (Pre-, Post-Incident) | \$40M |
| <ul style="list-style-type: none">– Fire Safe / Crash Resistant Fuel Systems– Detection / Suppression | |
| 2. Systems Approach to Crashworthiness | \$25M |
| 3. Systems Approach to Evacuation | \$20M |
| 4. Occupant Protection | \$15M |

Aviation System-Wide Monitoring, Modeling & Simulation Investment Areas

	<u>\$M</u>	<u>\$M - Total</u>
1. Data Analysis Tools	16.5	16.5
2. Aviation System Safety Mon.	8.75	25.25
3. Accident/Incident Causal Database	8.5	33.75
4. Data Sharing Technology	14.75*	48.5
5. Safety Data Studies & Tech.	19	67.5
6. Strategic Sys. Mgmt. Aids	17.5	85
7. Intra-Organizational & Participatory Safety Info. Sys.	10.75	95.75
8. High-fidelity Sys-wide Modeling	14.5	110.25
9. Next-Gen. Communication Tech.	18.5	128.75
10. Rapid Response Accident/ Incident Analysis & Sim.	11	139.75
11. System-wide Simulation Res.	14	153.75

*Assumes leveraging of \$14M from IT/ACNS & IT/IE

ASIST Recommendation 1:

Accept Suggested Investment Strategy

<u>Investment Area</u>	<u>Total \$M</u>	<u>~%</u>
Accident Prevention	\$532	75%
Accident Mitigation	\$65	9%
Aviation System-wide Monitoring, Modeling & Simulation	\$110	16%

ASIST Recommendation 2:

Assign Planning Responsibility in Coordination with the ASIST Team

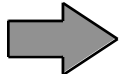
- **Select Focused Manager to support mid-May Transition “Sweatshop”**
- **Base PMs and Focused Manager form planning teams with input and support from appropriate individuals from ASIST Team**

ASIST Recommendation 3:

Support Studies to More Rigorously Link Solutions and Accident Rate Reductions

- **Historical Analysis of Accidents to Guide Research**
 - Boeing Transport Study on Approach & Landing Accidents
 - General Aviation Study
 - Rotorcraft Study
- **Scenario Planning for Identification of Future Safety Issues**

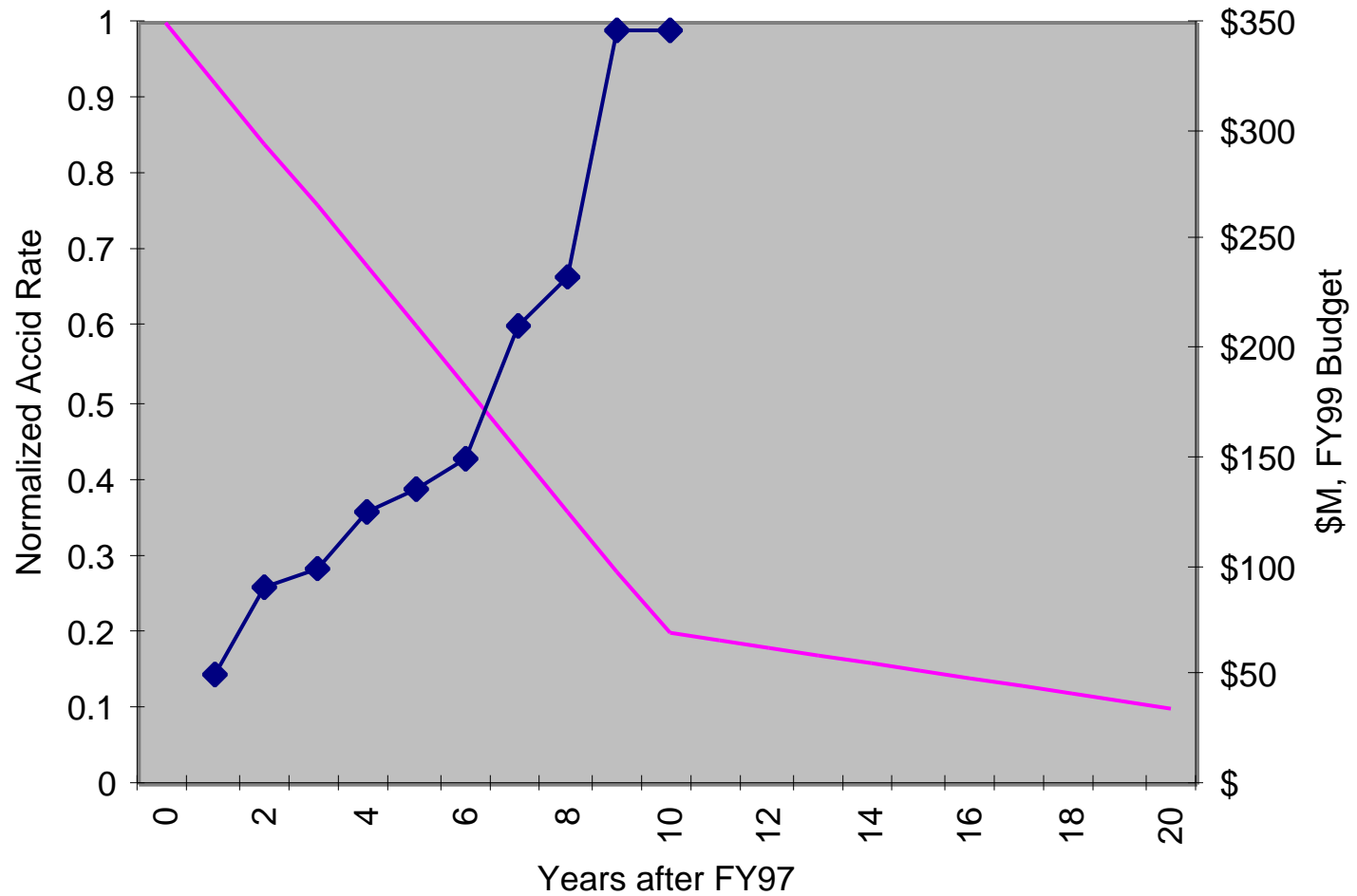
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Potential Issues

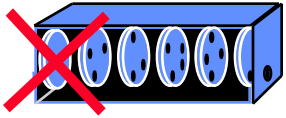
- **Skill Mix**
 - Scope by Transition Workshop
- **Proposed Program Resource Runout vs. Goals**
 - National Goal Requires Partnerships

Accident Goal vs Budget

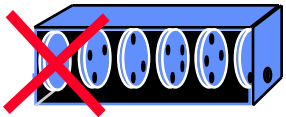


— Accident Goal —◆— 3/18/97 Code R FY99 Budget, \$M

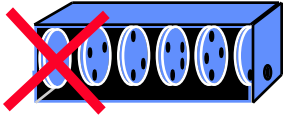
20-Year Visions



Aircraft and Aviation System-Wide Health Monitoring and Failure Prediction



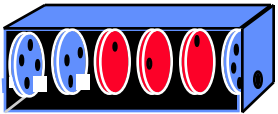
“Virtual VMC” Displays for Night/IMC Conditions



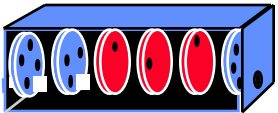
World-Wide Strategic Separation from Hazardous Weather, Traffic, and Terrain



Error-Proof Flight Decks



Measurable Training and Operator Proficiency



Guaranteed Flight Critical Information Integrity

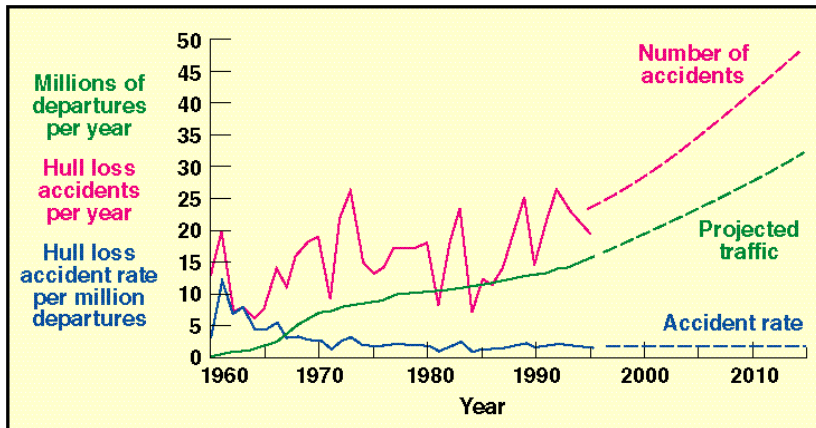


Damage Tolerant Aircraft and Control Systems



Crash-Survivable Aircraft Designs

ASIST Investment Strategy Enables Global Civil Aviation Pillar



**Accident Prevention
Solutions**

**Accident Mitigation
Solutions**

**Aviation System
Monitoring & Modeling**

Pillar One: . . . improving air transportation system Safety, affordability and Environmental Compatibility . . . Ten fold improvement in safety, 50% reduction in the cost of travel, reduction in emissions in the next 20 years

